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(54) PRODUCTION OF HYDROCARBONS BY THERMOLYSIS OF VEGETABLE OILS

(71) We, THE INDIAN SPACE RESEARCH ORGANISATION, Department of Space, 'F' Block, Cauvery Bhavan, District Office Road, Bangalore 560009, India, being an Indian Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the methods by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with a process for producing hydrocarbons from vegetable oils and the hydrocarbons so produced.

Production of hydrocarbons starting from vegetable oils has been attempted earlier and the work carried out in this line can be classified into four categories, viz. (a) conversion of vegetable oils to soaps by hydrolysis, followed by distillation of the soap, resulting in the formation of hydrocarbons, (b) hydrolysis of oils to get fatty acids and decarboxylation of the fatty acids in the presence of catalysts to get hydrocarbons, (c) direct decarboxylation of oils in the presence of catalyst to get hydrocarbons and (d) cracking of oils under pressure. The present invention falls in the category of (c); and the earlier work belonging to this category is described in the following paragraph (the Journal abbreviations are those employed by Chemical Abstracts).

A. Mailhe (Compt. rend. 173, 358—9, 1921; Ann. Chim. 17, 304—32, 1922; J. Usines Gaz. 47, 65—8, 1923; Comp. rend 177, 202—4, 1923; J. Usines Gaz. 46, 289—92, 1922; Chaleur et. Industries, 5, 3—5, 1924; J. Usines Gaz. 47, 321—4, 1923; Compt. rend, 177, 329—31, 1924) converted vegetable oils into hydrocarbons using metallic salts such as $MgCl_2$, $ZnCl_2$, Copper turnings and MgO at temperatures ranging from 300° to 700°C. In all the cases, in addition to hydrocarbons, he observed the presence of oxygenated compounds (as free acids) in the product. A Japanese patent No. 40, 623, claims the conversion of vegetable oils to a

greenish fluorescent liquid along with some free fatty acids, in the presence of Japanese clay catalyst at 900°C. G. Obarhausen, French Patent 682, 852 and British Specification 340, 107, converted vegetable oils such as soyabean and peanut into hydrocarbons in the presence of Fe, Zn or Cu and used them as motor fuel. However, some oxygenated compounds have been reported in the products. K. Ping and other Chinese workers, (J. Chinese Chem. Soc. 3, 281—7, 1935; Chinese industry 1, 2021—39, 1935; J. Chem. Eng. China 3, 201—10, 1936; J. Chem. Eng. China 3, 231—9, 1936; J. Chinese Chem. Soc. 8, 100—7, 1941; J. Chinese Chem. Soc. 18, 95—102, 1951) have reported conversion of vegetable oils into petroleum type hydrocarbons using $AlCl_3$, CaO , $NaOH$, $ZnCl_2$, $CaCl_2$, Fe , Fe_2O_3 and $Ca(OH)_2$ as catalyst at a temperature between 250° and 1000°C. The products obtained are reported to be gasoline (which was inferior in knock-rating), kerosene, high boiling fractions and unreacted fats. M. Friedwald, (Rev. Petrolifeze No. 734, 597—9, 1937) subjected oil seeds to temperatures of the order of 500 to 550°C and distilled the resulting oil in the presence of a catalyst and obtained a product containing 50% crude oil, 15 to 20% coke, the rest unreacted fats. Edovard G M Lese British Specification No. 485, 123 described the production of a blackish green fluorescent oil, smelling like petroleum, when fats, vegetable oils, palm oil and fish oil were subjected to distillation at 250° to 600°C in the presence of alkali salts, weak acids, amphoteric oxides, alkali silicates, aluminates, carbonates, titanates, vanadates, uranates and plumbates. M. R. Mandalekar et. al (J. Sci. Ind. Research, India, 5B, 45—7, 1946; Ind. Chem. Soc. Ind. News, Ed. 10, 1—16, 1947) described the conversion of peanut, castor, cotton and coconut oils by vapour cracking using fire-clay as catalyst. In the products, they obtained olefins and saturated hydrocarbons. Further references are seen in

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the chemical literature regarding conversion of vegetable oils to hydrocarbon products, contaminated with oxygenated compounds, utilising different methods like catalysis by Bentonite clay (Genoziz Nefia Gaza, Moscow, 146—51, 1967), by irradiation (Bertold Inst. Chem. tech. and Tech. Uni Muen Chen Preising Weihenstephan Ger. 2 Leibension Utans Forch. 55 (J.), 1—9, 1974), by pressure autocalving (Ind. Engg. Chem. 24, 1429, 1932; J. Chinese Chem. Soc. 4, 157—71, 1936), by using sodium carbonate and acetate together with iron (Non Petrole roumain 39, 699—702, 1938). Dalal and Mehta (J. Indian Chem. Soc. Ind. News. Ed. 2, 213—45, 1939) have reported that by cracking of coconut oil, ground nut oil, sesame oil and mahua oil in the presence of iron at 300° to 500°C, followed by distillation in the presence of $ZnCl_2$ under pressure of 45 to 300 psi, products like liquid hydrocarbons together with solid residues are obtained. Fa Wu Cheng (Che. & Met. Eng. 52, 1, 99, 1945), Y. C. Sun (J. Chinese Chem. Soc. 8, 108—11, 1941) and Tsung, Shih Le and Liu shang Tsai (J. Chinese Chem. Soc. 6, 1—7, 1938) obtained a gasoline type product together with high boiling fractions by pressure cracking of tung oil, mustard oil, cotton seed oil, oleic acid, linolic acid and palmitic acid.

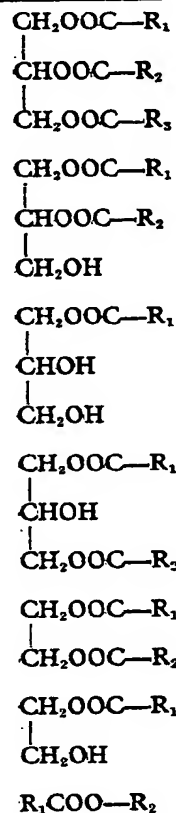
According to this invention there is provided a process for producing hydrocarbons from vegetable oils which comprises pyrolysing said oil at a temperature from 300°C to 700°C in the presence of a catalyst, said catalyst comprising silica-alumina in admixture with an oxide of a transition metal of groups IIA, IIIA, IVA, VA, VIA, VIIA or VIII of the periodic table.

The present process can be operated in a manner such that the resulting hydrocarbon product is substantially free from oxygenated compounds other than carbon dioxide and water.

The pyrolysis can be carried out in a fluidized bed, moving bed or fixed bed continuous tubular reactor, and can be effected at atmospheric pressure. In a preferred mode of operation, the reaction is carried out such that the boiling point, at atmospheric pressure, of 95% of the total hydrocarbon product is below 400°C.

The hydrocarbon or hydrocarbons produced can be separated and purified, for example, one can separate the product into more volatile hydrocarbons and less volatile hydrocarbons by partially condensing the product.

The vegetable oil employed can be edible or inedible, and will usually comprise at least one compound of the following formulae:



in which R_1 , R_2 and R_3 (which may be the same or different) represent saturated or unsaturated, branched chain, straight chain or cyclic hydrocarbon radicals having from 6 to 24 carbon atoms.

The relative amounts of liquid hydrocarbon and gaseous hydrocarbon produced at a given temperature and pressure after partially condensing the product can be controlled by adjusting the liquid hourly space velocity (LHSV) of the vegetable oil feed. Equally, the relative amounts of liquid hydrocarbon and gaseous hydrocarbon produced at a given pressure for a given liquid hourly space velocity (LHSV) of the vegetable oil feed can be controlled by adjusting the reaction temperature.

The transition metal oxide employed is an oxide of a metal of groups IIA, IIIA, IVA, VA, VIA, VIIA, or VIII of the periodic table such as is to be found on the inside back page of "Advanced Inorganic Chemistry", third edition, Cotton and Wilkinson, Interscience publishers, 1972. For the present purposes we treat the Lanthanides as transition metals in group IIIA. Suitable transition metal oxides thus include molybdenum, zirconium and

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titanium, or, for example, platinum, chromium, nickel, magnesium, vanadium or cerium.

When gaseous hydrocarbons are produced it is preferred that 50—70% by volume of said gaseous hydrocarbons consists of olefins having 3 or 4 carbon atoms.

The catalyst tends to lose efficacy during continuing operation of the process; it can be regenerated by passing air through it at temperatures of 400—600°C.

Certain aspects of the invention will now be described in more detail:—

When vegetable oils are brought into contact with the present catalysts at reaction temperatures of 300—700°C, preferably 400—500°C under atmospheric pressure, they give rise to gaseous and liquid hydrocarbons. On increasing the reaction temperature from 300 up to 700°C, the yield of liquid hydrocarbon decreases and that of gaseous hydrocarbon increases. The process can readily be operated such that no oxygen containing compounds (other than H₂O and CO₂) are formed and such that the liquid product is practically free from oxygenated compounds.

C₃ and C₄ olefins constitute 50 to 70% by volume of the gaseous hydrocarbons, the rest being saturates. Traces of C₅ hydrocarbons can be detected in the gaseous stream. The percentage yield of liquid hydrocarbons increases and that of gaseous hydrocarbons decreases when the liquid hourly space velocity (LHSV) of the vegetable oil fed to the continuously operating reactor is increased, keeping the other experimental parameters like temperature and pressure constant. The liquid hydrocarbons, when subjected to distillation, yield four different cuts; from initial boiling point (IBP) to 200°C (15 to 60% by volume), 200° to 250°C (10 to 30% by volume), up to 250°C under vacuum (10 to 30% by volume) and higher boiling liquids (10 to 30% by volume). In all the cases, the liquid hydrocarbons, when subjected to IBP distillation according to ASTM D1078, Part 20 (1970) give 95% products distilling below 380°C. Thus, the present invention describes a process which can be employed to produce light petroleum like hydrocarbons irrespective of the vegetable oil used.

The catalyst used in these reactions can be prepared as follows:—

Aqueous sodium silicate solution (10 to 70% by weight in water) is heated to 40° to 100°C and boiling mineral acid, like HNO₃ or H₂SO₄ (40 to 80% concentration), is added till the pH of the solution is between 4 and 1 when hydrated silica is precipitated. Aluminium salt solution, either as sulfate, nitrate, or an aluminate is added in hot condition to the precipitated hydrated silica solution. Impregnating transition metal salt solution is added to the above, under agitation. The solution is allowed to stand for 10 to 15 hrs. Then the pH of the solution is increased to

6 to 7 by adding an alkali solution, such as NaOH or NH₄OH. In the presence of already precipitated hydrated silica, the aluminium and the impregnating transition metal get precipitated as hydroxides under these conditions. The solution is allowed to stand for a period of 24 to 96 hrs. The precipitate from this solution is recovered by centrifuging and is then washed with distilled water till it is free from sulfate ions. The filtered precipitate (gel) containing 40 to 90% moisture is extruded into strands and the gel strands are dried at 100° to 120°C for 24 hrs. The gel strands shrink after drying and are cut into 5 to 10 mm long pieces and sintered at 500° to 600°C for 4 to 8 hrs. The catalyst, after sintering, is allowed to cool and is stored.

A typical reactor arrangement is shown in the accompanying drawing and the process procedure is as follows:—

The reactor used for the conversion of vegetable oils into hydrocarbons, is of the fixed bed type but the method is equally applicable to moving and fluidised bed type reactors. The reactor shown in the accompanying drawing is 1-1/4" stainless steel tube (7). It consists of three zones namely preheating zone (I), reaction zone (II) and post reaction zone (III). The preheating and post reaction zones contain stainless steel beads (2). The reaction zone is filled with catalyst (5). The three zones are heated independently by heating coils (3); the preheating zone by coil numbered 14, reaction zone by coil numbered 13 and the post reaction zone by coil numbered 12. The temperatures of each zone is measured by independent thermocouples (4). When these zones attain the preset temperatures, the vegetable oil is fed into the reactor through the inlet (1). The oil feed rate is controlled by means of a feed valve (not shown in the figure). The temperatures in the three zones are maintained at the required levels. To prevent heat loss, the reactor system is insulated (6).

The catalyst can convert vegetable oils roughly up to fifteen times of its volume before regeneration of the catalyst. The liquid products are tested spectroscopically, say, every fifteen minutes for the presence of oxygenated compounds. The oil feed is stopped when oxygenated compounds are detected and the catalyst is regenerated by passing air through the catalyst bed while keeping temperature always below 600°C, either by controlling the flow rate or air let in or by cooling the catalyst bed externally. The completion of the catalyst regeneration reaction is indicated by the decrease in temperature of the catalyst bed. On completion of regeneration, the passage of air into reactor is discontinued and vegetable oil feed for conversion is started.

The products from the reactor pass through a condenser (IV) through a stainless tube

(15). The condenser is cooled by means of water entering through the inlet (8) and leaving through the outlet (9). The cooled, condensed products from condenser pass through a separator (V). Here the uncondensed gases are drawn out through the gas outlet (10) and the liquids are drawn out through a bottom outlet (11). The condensed liquid products contain hydrocarbons similar to those present in petroleum crude. The gaseous products are passed through alkali solution (KOH solution) to remove CO₂ and then through dried silica gel to remove moisture to obtain pure dry gaseous hydrocarbons.

The following examples illustrate the typical methods of preparation of the catalyst and converting different types of oils into hydrocarbons:—

Example 1.

Catalyst (TISIAL-1) preparation

2.8 kg of sodium silicate (containing 34% silica by weight) is diluted with 14 litres of distilled water and heated to 90°C. Nitric acid (69%), diluted with an equal volume of distilled water, is heated to boiling and added to the hot sodium silicate solution under agitation till the pH comes down to around 1 (about 1.8 litres of dilute boiling nitric acid is required) when hydrated silica is precipitated. 1.050 kg of aluminium sulfate (Al₂(SO₄)₃·16H₂O) dissolved in 3.5 litres of distilled water is added to the precipitated hydrated silica solution followed by 82.5 ml of titanyl sulfate solution (concentration 8.6 g of TiO₂ per litre of solution) with agitation. The agitation is continued for 30 to 35 minutes. The solution is allowed to stand for 15 hrs. NH₄OH (12.5% concentration) is added to the above solution while stirring until the pH increases to 6 to 6.5 (around 2.4 litres of ammonia solution is required). In the presence of already precipitated hydrated silica, the aluminium hydroxide together with titanium hydroxide is precipitated under these conditions. The precipitates in suspension are thoroughly agitated for half an hour and allowed to stand for 96 hrs. The precipitate is filtered and washed with acidified distilled water (acidified with HNO₃ to a pH of 4 to 5) till the washings indicate the absence of SO₄ ion as tested by BaCl₂ solution. (Approximately 50 litres of distilled water is required). The precipitate (gel) containing 80 to 85% moisture is extruded through a 6 mm diameter die. The gel strands are dried for 24 hours at 110°C. The strands shrink to around 4 to 5 mm diameter after drying. The dried strands are cut into around 8 to 10 mm pieces and sintered at 600°C for 6 hrs. The heating to 600°C and cooling are carried out gradually. When the catalyst strands are cooled down to room temperature, they exhibit sufficient mechanical properties to with-

stand the reaction conditions. The catalyst thus obtained will weigh around 1 kg.

The catalyst made as described above was used as described under the typical reactor arrangement and process procedure, described earlier, for the conversion of vegetable oils into hydrocarbons. The results are given under Example 5, Table 1.

Example 2.

Catalyst (TISIAL-2) preparation:

The precipitation of hydrated silica is carried out in the same manner as explained in Example 1. The pH of this solution is kept at around 1. 435 g of sodium aluminate dissolved in 3.5 litre of distilled water is added to the precipitated hydrated silica solution under agitation. The pH of the solution is raised to around 10. The pH is brought down to around 1 by adding boiling dilute nitric acid (69% acid diluted with an equal volume of distilled water). 82.5 ml of titanyl sulphate solution (concentration 8.6 g of TiO₂ per litre of solution) is added to this under agitation. The solution is stirred thoroughly for about 30 minutes and allowed to stand for 15 hrs. 12.5% ammonia solution is slowly added to this solution till the pH comes to 6 to 6.5 (about 2.1 litres of ammonia is required). The aluminium and titanium hydroxides are precipitated in these conditions. The precipitated solution is stirred thoroughly for about 30 minutes and allowed to stand for 90 hrs.

The further processing of the precipitated gel is same as given in Example 1.

The catalyst made as described above was used as described under the typical reactor arrangement and process procedure, described earlier, for the conversion of vegetable oils into hydrocarbons. The results are given under Example 5, Table 1.

Example 3.

Catalyst (ZIRSIAL) preparation:

The procedure for the preparation of this catalyst is the same as explained in Example 1 except that in the place of titanyl sulphate, zirconium nitrate solution prepared in the following manner is added.

7 g of zirconium metal is dissolved in concentrated nitric acid (by HF treatment). Ammonia solution is added to this to precipitate zirconium as its hydroxide. The precipitate is washed with distilled water till it is free from fluoride ions and then dissolved in dilute nitric acid (1 volume of 69% acid mixed with 3 volumes of distilled water) to obtain zirconium nitrate solution.

The catalyst made as described above was used as described under the typical reactor arrangement and process procedure, described earlier, for the conversion of vegetable oils into hydrocarbons. The results are given under Example 5, Table 1.

Example 4.

Catalyst (MOSIAL) preparation:

300 g of sodium silicate (containing 34% silica by weight) is dissolved in 2 litres of distilled water and heated. 7 g of ammonium molybdate is dissolved in 500 ml of distilled water and this solution is added to the hot sodium silicate solution. This mixed solution is heated to 90°C and boiling nitric acid solution (69% acid diluted with an equal volume of distilled water) is slowly added to this with agitation till the pH is brought down to around 1. Hydrated silica is precipitated at this pH. 150 g of aluminium sulphate ($\text{Al}_2(\text{SO}_4)_3 \cdot 16\text{H}_2\text{O}$) is dissolved in 500 ml of distilled water and added to the solution at pH 1 and stirred thoroughly for about 20 minutes. The solution is allowed to stand for 15 hrs. 12.5% ammonia solution is added to the solution while stirring until the pH increases to 5 to 6 (about 15 ml of ammonia solution is required) when the hydroxides of aluminium and molybdenum are precipitated. The precipitate (gel) is allowed to stand for 15 hrs. The gel is washed with 6 litres of acidified distilled water (acidified with HNO_3 to a pH of 4 to 5). The gel containing 80 to 85% water is extruded and dried in the oven for 24 hrs at 110°C. The further processing of the catalyst is same as given in the Example 1.

The catalyst made as described above was used as described under the typical reactor arrangement and process procedure, described

earlier, for the conversion of vegetable oils into hydrocarbons. The results are given under Example 5, Table 1.

By adopting similar procedures catalysts containing the following impregnation metals in place of titanium, zirconium etc. have been prepared and the resultant catalysts have been named as given in parenthesis below:

- (a) Platinum as oxide (PLATSIAL)
- (b) Chromium as oxide (CHROSIAL)
- (c) Nickel as oxide (NISIAL)
- (d) Magnesium as oxide (MAGSIAL)
- (e) Vanadium as oxide (VASIAL)
- (f) Cerium as oxide (CESIAL)

The catalysts made as described above were used as described under the typical reactor arrangement and process procedure, described earlier, for the conversion of vegetable oils into hydrocarbons. The results are given under Example 5, Table 1.

Example 5.

Conversion of rubber seed oil into hydrocarbons:

Experiments were conducted with rubber seed oil as feed, at liquid hourly space velocity of around 0.3 lit/lit/hr, at 480°C using the different catalysts mentioned earlier in the manner described under the typical reactor arrangement and process procedure. The results are given in Table 1.

TABLE 1

No.	Catalyst used	LHSV lit/lit/ hr.	% of liquid hydrocarbons (vol % of feed)	Water (vol % of feed)	Gaseous products in lit (at NTP)/ lit of feed
1	TISIAL-1	.35	55.6	2.73	188
2	TISIAL-2	.29	50.0	3.00	208
3	ZIRSIAL	.23	51.8	2.10	181
4	MOSIAL	.28	53.2	2.00	231
5	PLATSIAL	.24	46.8	2.10	156
6	CHROSIAL	.23	20.6	2.00	403
7	NISIAL	.24	52.0	2.00	217
8	MAGSIAL	.26	64.5	2.10	121
9	VASIAL	.28	51.3	2.15	166
10	CESIAL	.28	55.0	2.08	208

The organic liquid products obtained are found to be free from oxygenated compounds as per the spectroscopic analysis. The gaseous products are found to contain CO₂ in amounts around 30% by weight.

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Example 6.

Effect of temperature on product pattern:

Experiments conducted at different reaction temperatures using rubber seed oil, as feed, are summarised in Table 2.

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TABLE 2

Feed			Rubber seed oil		
Catalyst	LHSV lit/lit/ hr.	Reaction Temperature	% of liquid hydrocarbons (% vol of feed)	Gaseous products in lit. (at NTP)/ lit of feed	Water (vol % of feed)
TISIAL-1	.35	480°C	55.6	188	3.73
	.35	420°C	65.0	128	3.00
MOSIAL	.283	480°C	53.2	231	2.00
	.283	420°C	66.0	141	2.10

The organic liquid products obtained are found to contain no oxygenated compounds when analysed spectroscopically. The gaseous products are found to contain CO₂ in amounts around 30% by weight.

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Example 7.

Effect of liquid hourly space velocity on product pattern:

Experiments conducted at different liquid hourly space velocities using rubber seed oil as feed at 420°C are given in Table 3.

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TABLE 3

Feed : Rubber seed oil

Reaction temperature : 420°C

Catalyst	LHSV	Liquid hydrocarbons (vol % of feed)	Gaseous products in lit (at NTP)/ lit of feed	Water (vol % of feed)
MOSIAL	.283	66.0	141	2.1
	.400	71.8	96	2.0

The organic liquid products are found to be free from oxygenated compounds when analysed spectroscopically. The gaseous products are found to contain CO₂ in amounts around 30% by weight.

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Example 8.

Conversion of different oils into hydrocarbons:

Experiments conducted with different oils and oil mixtures using TISIAL-1 Catalyst at 480°C are summarised in Table 4.

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TABLE 4

Catalyst : TISIAL-1

Reaction temperature : 480°C

No.	Feed	Liquid hydrocarbons				Gaseous products in lit (at NTP)/lit of feed	Water (% vol of feed)
		Total (vol % of feed)	IBP (°C) (% of total liquid hydrocarbons)	IBP to 200°C	200 to 250°C	Up to 250°C under vacuum	
1	Rubber seed oil	47.4	38.0	55.0	24.0	18.0	237
2	Mahua oil	55.5	40.0	52.0	18.0	17.0	188
3	Karanja oil	56.8	40.0	53.0	20.0	17.5	200
4	Sal oil	49.7	37.0	51.0	16.0	24.0	142
5	Rubber seed+ Karanja+ Punna oils (1:1:1)	46.4	41.0	55.0	18.0	18.0	188
6	Punna oil	50.0	40.0	50.0	17.0	20.0	222
7	Ground nut oil	50.6	40.0	57.0	17.0	12.0	188
8	Sesame oil	55.0	40.0	50.0	16.0	14.0	176
9	Castor oil	58.0	42.0	53.5	14.6	14.0	181

Example 9.

Catalyst regeneration

Table 5 gives the conditions of regeneration

and details of number of regenerations carried out and the total quantity of oil converted in a straight run by 1 kg of catalyst.

TABLE 5

Feed : Rubber seed oil

Temperature : 480°C

LHSV : 0.205

	Fresh catalyst	1st regeneration	2nd regeneration	3rd regeneration	4th regeneration
kg of oil cracked/ kg of catalyst	10.6	10.6	10.4	10.4	10.3
liquid hydrocarbons (% vol of the feed)	59.5	54.5	56.5	60.0	57.2
Gaseous products lit (at NTP)/lit of feed	204.0	189.0	190.0	183.0	218.0
IBP of liquid hydrocarbons (°C)	38.0	38.0	40.0	40.0	38.0
Vol % of fractions of total liquid products: IBP to 200°C	58.0	54.0	57.0	56.0	58.0
200°C to 250°C	20.0	21.0	20.5	21.5	21.0
Under vacuum up to 250°C	10.0	11.0	12.0	11.5	10.5

WHAT WE CLAIM IS:—

1. A process for converting an ester-containing vegetable oil into one or more hydrocarbons which comprises pyrolysing said oil at a temperature from 300°C to 700°C in the presence of a catalyst, said catalyst comprising silica-alumina in admixture with an oxide of a transition metal of groups IIA, IIIA, IVA, VA, VIA, VIIA, or VIII of the periodic table.

2. A process according to claim 1, in which the pyrolysis takes place in a fluidised bed, moving bed or fixed bed continuous tubular reactor.

3. A process according to any of the preceding claims which takes place at atmospheric pressure.

4. A process according to any of the preceding claims, which additionally comprises separating and purifying the resulting hydrocarbon or hydrocarbons.

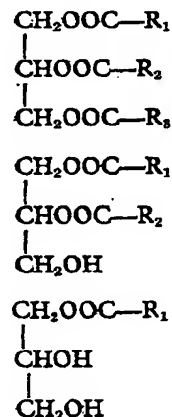
5. A process according to any of the preceding claims, in which the resulting product, before purification, is substantially free from oxygenated compounds other than carbon dioxide and water.

6. A process according to any of the preceding claims, which additionally comprises separating the product into more volatile

hydrocarbons and less volatile hydrocarbons by partially condensing the product.

7. A process according to any of the preceding claims, in which the boiling point, at atmospheric pressure, of 95% of the total hydrocarbon product is below 400°C.

8. A process according to any of the preceding claims, in which said vegetable oil is an edible oil or an inedible oil comprising at least one compound having the formula





or



in which R_1 , R_2 and R_3 , which may be the same or different, represent saturated or unsaturated, branched chain, straight chain or cyclic hydrocarbon radicals having from 6 to 24 carbon atoms.

9. A process according to claim 6, in which the relative amounts of liquid hydrocarbon and gaseous hydrocarbon produced at a given pressure and temperature after said partial condensation, is controlled by adjusting the liquid hourly space velocity (LHSV) of the vegetable oil feed.

10. A process according to claim 6, in which the relative amounts of liquid hydrocarbon and gaseous hydrocarbon produced at a given pressure for a given liquid hourly

space velocity (LHSV) of the vegetable oil feed is controlled by adjusting the reaction temperature.

11. A process according to any of the preceding claims, in which said metal is molybdenum, zirconium or titanium.

12. A process according to any of claims 1 to 10, in which said metal is platinum, chromium, nickel, magnesium, vanadium or cerium.

13. A process according to any of the preceding claims, in which gaseous hydrocarbons are produced.

14. A process according to claim 13, in which from 50 to 70% by volume of said gaseous hydrocarbons consists of olefins having 3 or 4 carbon atoms.

15. A process according to any of the preceding claims, in which said catalyst is subsequently regenerated by passing air over it at a temperature from 400 to 600°C.

16. A process according to claim 1, substantially as herein described, with reference to any of examples 5 to 8 and to the accompanying drawing.

17. A hydrocarbon when produced by a process according to any of the preceding claims.

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COMPLETE SPECIFICATION

1 SHEET

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